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Original Article

EFFECT OF WATER STRESS AT TILLERING STAGE ON DIFFERENT MORPHOLOGICAL TRAITS OF RICE (*ORYZA SATIVA L*) GENOTYPES

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ABSTRACT

To estimate genetic variability and relationships among some morphological traits of rice an experiment was conducted with 12 genotypes of rice under two irrigation regimes at the Instructional Farm of Jaguli, Department of Genetics & Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia (W.B), during Rabi season, 2013. There were significant differences among the genotypes for all traits. Evaluation of phenotypic and genotypic co-efficient of variations (CV) showed that the lowest and highest phenotypes CV and genotypic CV under both hydrological regimes were observed for root to shoot ratio and the number of filled grains per plant followed by grain yield per plant respectively. Furthermore, the traits number of filling grains/panicle, yield/plant and spikelet fertility percentage showed high heritability with high genetic advance under both irrigation regimes. Plant height, root length, flag leaf length, flag leaf area, panicle length and number of filling grains/panicle under optimum irrigated condition were significantly and positively correlated with grain yield/plant, whereas almost all traits were significantly positively correlated with grain yield under stress condition except flag leaf angle which was negatively correlated with grain yield/pant. Path analysis for paddy yield per plant indicated number of filled grains/panicle had positive direct effect on grain yield/plant in both hydrological regimes. Hence, for improving the rice yield under drought ecology, a genotype should posses a large number of filled grains per panicles, high spikelet fertility and maintains larger root length.

***KEYWORDS:** Correlation, Drought, Grain Yield, Genetic Advance, Heritability, Path Coefficient & Rice*

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INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than three billion people in the world, most of who live in Asia. Asia can be considered as 'Rice Basket' of the world, as more than 90 per cent of the rice is produced and consumed in Asia, a region with high population density. Worldwide, rice is cultivated in an area of 154 million hectares with an annual production of 700 million tons (FAO, 2011). Being the staple food for almost two thirds of the population supplying almost 31% of calories of the Indian diet, rice plays a pivotal role in Indian economy (Ravindra Babu, 2013). India ranks first in the world in the area of rice cultivation with 43.97 million ha and second in production with 104.32 million tons (Anon., 2013). Water is a main resource for rice production, but the recent availability of water resource constitutes most vital factor behind rice growth and its production. Global climate change accompanied by unpredictable and uneven rainfall patterns created concern to the plant breeders for limited

water supply and to take the gigantic task to evolve lines adapted to water stress condition with less fluctuation in grain yield compared to favorable water availability. A definition of drought generally accepted by plant breeders is: “a shortfall of water availability sufficient to cause loss in yield” (Price A.H. 2002) or “a period of no rainfall or irrigation that affects crop growth”. Drought stress is a multidimensional stress that affects plants at different growth stages. The impact of drought stress on the total green plant surface and plant response to drought stress are very intricate, because it reflects a combination of stress impacts and plant response in all essential levels of plant over time and place (Blum, 1996). Drought is a major a biotic stress that limits rice productivity in rain fed and upland ecosystems and worldwide. Drought stress is not only limited to arid or semiarid areas, but also sometimes, due to irregular distribution of rain, causes a significant decrease of plant yield. Stress in the tillering stage happened to have some inverse effect on the number of effective tillers, flag leaf length and area and there are some lines which are capable to withstand the stress when water availability becomes almost normal (Venuprasad et al., 2009a; Lancer as et al., 2004). In India, an area under rice cultivation remained stagnant and even declined in the recent years due to water unavailability. Out of the total 20.7 million ha rain fed rice area reported in India, approximately 16.2 million ha lie in eastern India (Singh and Singh, 2000), of which 6.3 million ha of upland areas and 7.3 million ha of the low land area are highly drought-prone (Pandey and Bhandari, 2009). Eastern India, comprising Jharkhand, Orissa, and Chhattisgarh alone accounts loss of about 40 per cent of the total rice production due to severe drought (Pandey and Bhandari, 2009). Farmers of drought prone areas require varieties that provide them with high yield in years of good rainfall and sustainable good yield in years with drought. Exploring ways to produce more rice with less water is essential for food security. Breeding for drought tolerance in rice with high yield potential is quite challenging due to its complex genetic nature (polygenic nature), poor understanding of physiological as well as molecular mechanisms underlying the trait and intensity, timing and duration of drought stress in lowland and upland conditions across seasons. To achieve high and sustainable yields in non-flooded soil, identification of genotypes with better water use efficiency assumes great importance. In the present investigation the objective was outlined as to identify suitable adapted genotypes for stress environment with high and stable yield and to frame breeding proposal to develop high yielding genotypes with water stress resistance.

MATERIALS & METHODS

The experiment was carried out in randomized block design (RBD) with three replications under optimum irrigation and drought stress conditions at the Instructional Farm of Jaguli, Department of Genetics & Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Mohanpur, Nadia (W.B), during Rabi season, 2013. Twelve genotypes Dular, Kalinga III, Heera, Mtu 1010, Jaldi Dhan-13, IR-30, IR-36, IR-50, IR-64, Satabdi, Sitabhog and Jhu 11-26 collected by Chinsurah Rice Research Institute, West Bengal, India were considered in the experiment. Plot size for each genotype was 1m x 1m with spacing of 25 x 20 cm. The recommended agronomic practices were followed up to tillering stage. After tillering stage irrigation was withheld for 10 days in one set of experiment to impose artificial drought. Records on thirteen morphological characters were taken under both hydrological regimes. Such agro-morphological characters were planted height (cm), number of tillers/plant, Flag leaf angle, flag leaf length (cm), flag leaf breadth (cm), flag leaf area (cm^2), root characters like maximum root length (cm), root to shoot ratio and yield related character panicle length (cm), number of filling grains/panicle, test weight (g) and yield per plant (g) were recorded. The data were subjected to Analysis of Variance (Singh and Chaudhary, 1985), Genotypic and Phenotypic Coefficient of Variation (Burton, 1952), Genetics Advance (Johnson *et al.,* 1955 and Lush, 1949), broad sense Heritability (Hanson *et. Al.*, 1956), Correlation Coefficient and Path Coefficient analysis (Dewey and Lu, 1959).

RESULTS & DISCUSSIONS

The analysis of variance for two hydrological regimes (optimum irrigation and drought stress) for the shoot and root characters (viz. Plant height, leaf length, leaf brads, leaf area, leaf angle, maximum root length, root to shoot ratio and the number of tillers/plant) have been presented in the Table 1. The results showed that there were significant differences among genotypes considering the characters in both hydrological regimes. Thus, these significant differences among varieties showed high genetic variability in studying populations, for these traits and provided ample scope to select desirable lines appropriate for less water environments.

The mean performance of cultivars studied has been presented in Table 2. The mean of all traits showed the lower value in drought stress condition compared to optimum condition. The best yield per plant was noticed from genotypes Sitabhog (23.46 g) followed by IR-64 (19.66 g), Dular (19.34 g) and Satabdi (17.61 g) in non stress condition, but under drought stress environment these genotypes suffered to a great extent with substantial reduction in grain yield. The genotypes which showed least reduction in stress situation were duller, Heera, Jaldi than 13, Kalinga III and Zhu 11-26. Estimation of coefficient of variation, heritability (broad sense), genetic advance (GA) at 5% selection intensity and genetic advance as percent over mean for thirteen characters of twelve genotypes under two hydrological regimes are presented in the Table 3. The magnitude of the PCV was found to be marginally higher than GCV for all the traits except number of tillers/plant under two water available conditions which indicated the least influence of environment on these traits except number of tillers/plant which provided enough scope to select genetically superior plants on the basis of phenotypic characters which were reflected sound for presence. Girish *et al*., (2006) had a similar observation. Variation was found to be conspicuously increase for characters root length, number of tillers/plant, spikelet fertility percentage and selection for stress should be emphasized on these characters. Heritability is the ability of the characters to inherit into subsequent generations. Heritability of a trait is important because it determines the extent to which plant improvement through selection is possible. Some traits that are highly heritable under non-stress (fully irrigated) conditions may not be heritable under the drought stress conditions, suggesting that selection under non-stress conditions would not identify genotypes that would perform well under stress. The traits with high heritability under the stress conditions could be useful to enhance grain yield. Blum (1988) and Efisue *et al*., (2009) reported that genetic variance and heritability for grain yield decline under stress. Therefore, they stressed the importance of secondary traits as predictors of grain yield under stress conditions. Heritability estimates were observed to be high for yield per plant (95.40 & 94.50), plant height (96.65 & 95.29), number of filling grains per panicle (94.25 & 99.42), spikelet fertility percentage (91.24 & 98.80) and test weight (90.99 & 93.92) under both control and stress condition. Hence selection would be effective for improvement of these characters. Selection for grain yield under drought stress is now a well-recommended selection criterion for breeding drought-tolerant rice varieties (Kumar *et al*., 2008). High heritability across water regimes had also been reported in rice (Jonaliza *et al*., 2004). High to moderate heritability was reported for different quantitative traits studied in rice by Vikram *et al*., (2011) and Saikumar *et al*., (2014). Genetic advance in percent of the men was estimated high for the character number of filling grains per panicle (102.84 & 78.15), grain yield per plant (39.67 & 41.89) and spikelet fertility percentage (24.67 & 41.36) and low for the character's root to shoot ratio (9.07 & 11.14), tillers per plant (8.25 & 29.75) and flag leaf length (14.87 & 10.83) in both hydrological regimes. Further traits such as number of filled grains per panicle, spikelet fertility percentage and yield per plant recorded high heritability as well as genetic advance under both control and stress conditions and the traits are mainly controlled by additive gene action and selection on the basis of their phenotypes could be improved as was noted by Warkad *et al*., 2008. Although other traits showed high heritability values, expected

genetic advance was low or moderate to inconsistent. Further, these traits showed high GCV and PCV values, suggesting the presence of enough variation to ease the selection process and simple breeding method could be followed for improvement of these characters.

Phenotypic and genotypic correlation coefficients of study traits under both water regime and drought conditions are presented in Table 4 and 5, respectively. Genotypic and phenotypic correlations in optimum irrigation regime showed positive and significant correlation with paddy yield per plant and plant height (0.66** and 0.63**), flag leaf length (0.81** & 0.73**), flag leaf area (0.56** & 0.46**), root length (0.44** & 0.41*), panicle length (0.840** & 0.82**) and number of filling grains per panicle (0.87** & 0.81**). Abd El Samie and Hasan, (1994); Bapo and Soundarapandian, (1992); Choudhury and Das, (1998) and Padmavathi *et al*., (1996) observed significant positive correlation between yield and panicle length. Under stress condition grain yield per plant was significantly and positively correlated with plant height (0.46** & 0.44**), flag leaf length (0.72** & 0.64**), flag leaf area (0.38* & 0.34*), root length (0.67** & 0.65**), root to shoot ratio (0.69** & 0.65**), number of tillers per plant (0.65** & 0.53**), panicle length (0.59** & 0.52**), number of filled grains per panicle (0.82** & 0.79**), spikelet fertility percentage (0.62** & 0.59**). Gravity and O'Toole (1994) had also observed positive correlation between panicle fertility percentage and yield under water stress conditions. The positive correlation between grain yield and plant height, filled grains per panicle, spikelet fertility percentage, test weight, biomass yield and harvest index were also reported by Lancer as *et al*., (2004); Berneir *et al*., (2007) and Vikram *et al*., (2011). Flag leaf length and number of filling grains/panicle compared to other traits showed consistently high correlation with grain yield under both water situations. Significant and positive correlation between yield and other traits showed variable records under changed environments in these traits. Root to shoot ratio and spikelet fertility percentage was significantly and negatively correlated with grain yield/plant in optimum condition, but in stress these were positively and significantly correlated to it. Plant height, flag leaf length, root length, panicle length and number of filling grains/panicle were the determining factors in grain yield/plant where the major determining factor was number of filling grains/panicle. The complex natures of relationship between characters and with grain yield/plant (g) become evident from the above discussion. Such estimates of correlation co-efficient alone do not provide a comprehensive picture of the relative importance of the direct and indirect influences of each character to the fruit yield/plant. As correlation co-efficient is insufficient to explain the relationship between characters, for an efficient manipulation of characters, path coefficient analysis was done.

In the present investigations yield/plant (g) was taken as a dependent or resultant variable and all the other characters, under study as independent or causal variables. The results of path co-efficient analysis were presented in Table 6 for both hydrological regimes. Under non stress situation root length followed by flag leaf area and flag leaf angle showed maximum direct effect on yield while under stress condition most of the traits exhibited direct influence on grain yield, traits such as plant height, flag leaf length, flag leaf breadth, flag leaf angle, root to shoot ratio, number of tillers/plant, number of filled grains/panicle and spikelet fertility percentage and these characters should be emphasized for selection of model plants to two respective water regimes. Path analysis under both hydrological regimes revealed that most of the traits had positive indirect effect on yield/plant through root length, root to shoot ratio, number of filled grains/panicle and spikelet fertility percentage. So it seems that, these traits were the most important influencing traits on paddy yield and these will be studied as good selection criteria in order to yield breeding programs. In past, many researchers have emphasized the importance of several quantitative yield component traits as selection criteria for deriving high yielding genotypes in different ecosystems in rice: for example, filled grains per panicle, spikelet fertility Seyoum *et*

al., (2012) and Pandey *et al.*, (2012) emphasized the importance of filled grains/panicle, spikelet fertility percentage and harvest index as selection criteria for deriving high yielding genotypes in different ecosystem. Thus, practical applicability of these traits in rice breeding programme either individually or in combination, as selection criterion represent an effective and feasible approach for pursuing higher yield in the case of rice, which may be due their high direct or indirect effect on grain yield. Mehetre *et al.* (1994) reported that, number of filled grain per panicle, plant height and panicle length are the most important and effective traits on yield for breeding of upland rice.

CONCLUSIONS

Results from the above study suggest that there is an adequate genetic variability present in the material studied under stress and irrigated condition. Further characters viz. Number of filled grains/panicle, spikelet fertility percentage, root length and root to shoot ratio influenced the yield either directly or indirectly. Genotypes Dular, Heera, Jaldi Dhan 13 and Kalinga III that are capable of maintaining high spikelet fertility, more filled grains per panicle and root length can be considered as suitable for improving the grain yield in rice breeding programs targeting drought.

Table 1: Analysis of Variance (ANOVAs) for Thirteen Different Characters of Rice Genotypes

			Mean Sum of Squares												
Source of Variation		D.F	PH	FLL	FLB	FLA	FLAn	RL	RSR	T/P	PL	FG	SF	TW	YP
Genotype	NS	11	42.93**	15.49**	0.01**	9.59**	28.08**	8.49**	0.00	0.75**	40.49**	5048.27**	217.41**	13.09**	32.03**
	S	11	41.34**	6.88**	0.01**	5.36**	31.33**	20.38**	0.00	3.02**	20.02**	2081.85**	461.47**	15.23**	24.94**
Replication	NS	22	0.10	1.26	0.00	0.18	1.68	0.37	0.00	0.03	0.18	48.03	32.71**	1.56**	0.33
	S	22	0.51	0.32	0.00	0.04	1.27	0.84	0.00	0.36	0.22	8.58	0.03	1.04	2.36**
Error	NS	22	0.49	0.72	0.00	0.42	1.24	0.47	0.00	0.27	0.90	100.63	6.75	0.42	0.51
	S	22	0.67	0.35	0.00	0.27	0.85	0.22	0.00	0.39	0.73	4.07	1.87	0.32	0.47
SE_d	NS		0.57	0.69	0.01	0.53	0.91	0.56	0.01	0.42	0.77	8.19	2.12	0.53	0.58
	S		0.67	0.48	0.01	0.43	0.75	0.39	0.01	0.51	0.70	1.65	1.12	0.46	0.56
CD (5%)	NS		1.19	1.44	0.02	1.10	1.88	1.16	0.02	0.88	1.61	16.99	4.4	1.09	1.2
	S		1.39	1.00	0.02	0.88	1.56	0.80	0.02	1.06	1.45	3.42	2.32	0.96	1.17

PH: Plant Height (cm); **FLL:** Flag Leaf Length (cm); **FLB:** Flag Leaf Breadth (cm); **FLAn:** Flag Leaf Angle (^{o}); **RL:** Root Length (cm); **RSR:** Root to Shoot Ratio; **T/P:** Number of Tillers/Plant; **PL:** Panicle Length; **FG:** Filled Grains/Panicle; **SF:** Spikelet Fertility %; **TW:** Test Weight; **Y/P:** Grain Yield/Plant; **CD:** Critical Difference; **SE_d:** Standard Error Deviation; **S:** Stress; **NS:** Non Stress * Significant at 5% ****** Significant at the 1 % level

Table 2: Mean Performance of Twelve Rice Genotypes for Thirteen Different Characters

		PH	FLL	FLB	FLA	FLAn	RL	RSR	T/P	PL	FG	SF	TW	YP
DUIAR	NS	48.17	33.00	0.67	22.12	13.67	**28.14**	0.58	**6.67**	25.55	102.67	**82.29**	**25.07**	**19.34**
	S	45.24	29.42	0.62	18.24	15.00	**25.64**	0.57	**6.33**	24.11	104.00	**84.33**	**23.67**	**18.83**
IR-64	NS	42.80	28.29	0.70	19.80	22.00	23.74	0.55	6.33	28.25	87.00	58.86	23.10	19.66
	S	37.01	24.71	0.63	15.57	19.33	19.40	0.52	4.67	25.89	98.33	50.52	21.77	15.87
IR-30	NS	42.88	27.54	0.77	21.30	20.67	23.92	0.56	7.00	19.39	60.67	66.09	22.20	16.73
	S	38.29	24.44	0.61	14.90	19.00	18.32	0.48	5.00	20.50	46.33	52.45	21.20	11.88
IR-50	NS	43.21	27.29	0.71	19.46	17.67	23.59	0.54	6.00	23.52	58.67	70.51	23.67	13.45
	S	38.92	24.33	0.62	15.17	20.00	18.88	0.48	4.33	18.82	53.33	63.76	21.87	11.46
IR-36	NS	42.14	27.38	0.74	20.17	21.67	24.85	0.59	6.33	20.18	67.33	62.65	21.83	13.40
	S	39.04	24.87	0.63	15.66	20.67	20.29	0.52	5.33	23.37	51.00	44.35	20.97	10.57
JALDI DHAN 13	NS	50.53	30.00	0.66	19.80	15.00	**26.83**	0.53	**5.67**	18.98	46.00	**57.51**	**21.37**	**14.91**
	S	46.18	27.32	0.54	14.66	16.67	**25.28**	0.55	**6.67**	25.33	74.00	**65.29**	**21.87**	**15.41**
HEERA	NS	42.13	28.25	0.62	17.52	14.67	**22.61**	0.54	**5.67**	20.90	77.00	**61.43**	**20.60**	**14.73**
	S	41.30	27.06	0.53	14.34	18.00	**21.74**	0.53	**6.67**	24.97	100.67	**68.48**	**21.53**	**18.24**
MTU 1010	NS	44.22	28.11	0.67	18.83	20.00	24.26	0.55	6.33	22.78	88.00	72.99	24.07	17.80
	S	37.33	25.04	0.56	14.03	21.67	18.73	0.50	4.33	23.23	68.33	58.74	21.67	12.54
SITABHOG	NS	53.34	32.88	0.60	19.83	18.67	25.93	0.49	5.33	28.54	197.00	57.71	18.37	23.46
	S	48.08	27.00	0.48	12.97	20.67	23.34	0.49	4.33	22.33	103.00	53.38	16.04	13.16
KALINGA III	NS	42.84	26.86	0.68	18.17	15.67	**24.87**	0.58	**5.67**	20.55	52.67	**58.37**	**24.17**	13.41
	S	40.13	26.77	0.53	14.19	16.67	**22.32**	0.56	**6.33**	20.50	43.67	**69.30**	**24.03**	13.70
SATABDI	NS	47.50	29.29	0.69	20.21	19.67	26.39	0.56	6.67	24.96	62.00	67.85	20.33	17.61
	S	37.68	25.87	0.59	15.17	27.33	18.30	0.49	4.33	22.50	30.33	47.05	19.40	9.78
ZHU 11-26	NS	42.34	25.59	0.60	15.27	14.00	22.90	0.54	**6.00**	17.14	48.67	**79.34**	**25.20**	12.77
	S	40.45	25.81	0.52	13.51	16.00	21.18	0.53	**6.33**	17.77	57.00	**77.73**	**24.63**	12.36
Overall Mean	NS	45.17	28.71	0.66	19.37	17.78	24.84	0.55	6.14	22.56	78.97	66.30	22.50	16.44
	S	40.80	26.05	0.57	14.87	19.25	21.12	0.52	5.39	22.44	69.17	61.28	21.55	13.65

PH: Plant Height (cm); **FLL:** Flag Leaf Length (cm); **FLB:** Flag Leaf Breadth (cm); **FLAn:** Flag Leaf Angle (^{0}); **RL:** Root Length (cm); **RSR:** Root to Shoot Ratio; **T/P:** Number of Tillers/Plant; **PL:** Panicle Length (cm); **FG:** Filled Grains/Panicle; **TW:** Test Weight (g); **SF:** Spikelet Fertility %; **YP:** Yield/Plant (g); **NS:** Non Stress; **S:** Stress

Table 3: Genetic Variability Parameters for Thirteen Different Characters of Twelve Rice Genotypes for Two Hydrological Regimes

Characters		Mean ± SE	Variance			Co-Efficient of Variation (%)			Heritability (Broad Sense)	Genetic Advance	Genetic Advance as % of Mean
			Gen	Phen	Env	GCV	PCV	ECV			
PH	NS	45.17 ± 0.57	14.16	14.64	0.004	8.33	8.47	0.14	96.65	7.62	16.86
	S	40.80 ± 0.67	13.54	14.21	201.99	9.02	9.24	0.22	95.29	7.4	18.15
FLL	NS	28.71 ± 0.69	4.93	5.65	0.03	7.73	8.28	0.55	87.20	4.27	14.87
	S	26.05 ± 0.48	2.17	2.53	6.38	5.66	6.1	0.44	86.11	2.82	10.83
FLB	NS	0.68 ± 0.01	0.003	0.003	0.00	7.69	7.94	0.25	93.92	0.10	15.35
	S	0.57 ± 0.01	0.00	0.00	0.00	8.90	9.19	0.29	93.71	0.10	17.74
FLA	NS	19.37 ± 0.53	3.06	3.48	0.01	9.03	9.63	0.60	87.84	3.38	17.43
	S	14.87 ± 0.43	1.69	1.97	3.87	8.75	9.43	0.68	86.13	2.49	16.73
FLAn	NS	17.78 ± 0.91	9.05	10.17	0.03	16.92	17.94	1.02	89.00	5.85	32.88
	S	19.25 ± 0.75	10.55	11.48	131.76	16.87	17.60	0.73	91.88	6.41	33.30
Rl	NS	24.84 ± 0.56	2.67	3.15	0.02	6.58	7.14	0.56	84.98	3.11	12.50
	S	21.12 ± 0.39	6.72	6.95	48.27	12.27	12.48	0.21	96.79	5.25	24.88
RSR	NS	0.55 ± 0.01	0.001	0.001	0.00	4.84	5.33	0.49	82.61	0.05	9.07
	S	0.52 ± 0.01	0.00	0.00	0.00	5.68	5.96	0.28	90.76	0.06	11.14
T/P	NS	6.14 ± 0.42	0.16	0.43	0.07	6.55	10.7	4.15	37.43	0.51	8.25
	S	5.39 ± 0.51	0.88	1.27	1.61	17.37	20.89	3.52	69.12	1.60	29.75
PL	NS	22.56 ± 0.77	13.19	14.09	0.02	16.1	16.64	0.54	93.62	7.24	32.09
	S	22.44 ± 0.70	6.43	7.15	51.19	11.3	11.92	0.62	89.78	4.95	22.05
FG	NS	78.97 ± 8.19	1648.88	1749.78	1.50	51.42	52.97	1.55	94.25	81.22	102.84
	S	69.17 ± 1.65	692.7	696.71	0.01	38.05	38.16	0.11	99.42	54.06	78.15
SF	NS	66.30 ± 2.12	70.23	76.94	0.15	12.64	13.23	0.59	91.24	16.49	24.87
	S	61.28 ± 1.12	153.23	155.05	24041.96	20.2	20.32	0.12	98.80	25.34	41.36
TW	NS	22.50 ± 0.53	4.22	4.65	0.01	9.13	9.58	0.45	90.99	4.04	17.95
	S	21.55 ± 0.46	4.97	5.29	27.95	10.34	10.67	0.33	93.92	4.45	20.65
YP	NS	16.44 ± 0.58	10.51	11.02	0.01	19.72	20.19	0.47	95.40	6.52	39.67
	S	13.65 ± 0.56	8.15	8.63	74.46	20.92	21.52	0.6	94.50	5.72	41.89

PH: Plant Height (cm); **FLL:** Flag Leaf Length (cm); **FLB:** Flag Leaf Breadth (cm); **FLAn:** Flag Leaf Angle (^{0}); **RL:** Root Length (cm); **RSR:** Root to Shoot Ratio; **T/P:** Tillers/Plant; **PL:** Panicle Length (cm); **FG:** Filled Grains/Panicle

SF: Spikelet Fertility % ; **TW:** Test Weight; **NS:** Non Stress; **S:** Stress; **CV:** Co-efficient of Variation; **PCV:** Phenotypic CV; **GCV:** Genotypic CV; **ECV:** Environmental CV **Gen:** Genotypic; **Phen:** Phenotypic; **YP:** Yield/Plant (g)

Table 4: Genotypic and Phenotypic Correlation Co-Efficient among Thirteen Characters of Rice Genotypes under Irrigated Condition

		PH	FLL	FLB	FLA	FLAn	RL	RSR	T/P	PL	FG	SF	TW	YP
PH	G	1.00												
	P	1.00												
FLL	G	0.88**	1.00											
	P	0.81**	1.00											
FLB	G	-0.38*	-0.25	1.00										
	P	-0.35*	-0.24	1.00										
FLAn	G	0.39*	0.60**	0.62**	1.00									
	P	0.37*	0.63**	0.61**	1.00									
FLA	G	-0.17	-0.14	0.65**	0.41*	1.00								
	P	-0.15	-0.14	0.57**	0.32	1.00								
RL														
RSR	G	-0.59**	-0.33*	0.60**	0.23	0.08	0.06	1.00						
	P	-0.52**	-0.27	0.53**	0.23	0.05	0.18	1.00						
T/P	G	-0.37*	-0.20	0.84**	0.57**	0.59**	0.15	0.73**	1.00					
	P	-0.24	0.03	0.56**	0.49**	0.22	0.08	0.43**	1.00					
PL	G	0.46**	0.66**	-0.06	0.48**	0.36*	0.35*	-0.27	-0.03	1.00				
	P	0.42*	0.60**	-0.05	0.44**	0.33*	0.30	-0.22	0.04	1.00				
FG	G	0.63**	0.74**	-0.39*	0.25	0.16	0.28	-0.60**	-0.43**	0.73**	1.00			
	P	0.60**	0.69**	-0.37*	0.25	0.11	0.26	-0.50**	-0.19	0.70**	1.00			
SF	G	-0.16	-0.03	-0.08	-0.06	-0.32	0.07	0.28	0.55**	-0.13	-0.17	1.00		
	P	-0.15	0.01	-0.06	-0.01	-0.34*	0.09	0.28	0.44**	-0.11	-0.12	1.00		
TW	G	-0.53**	-0.42*	0.12	-0.21	-0.30	-0.13	0.60**	0.40*	-0.32	-0.51**	0.67**	1.00	
	P	-0.51**	-0.39*	0.12	-0.190	-0.27	-0.14	0.50**	0.25	-0.27	-0.46**	0.62**	1.00	
YP	G	0.66**	0.81**	-0.16	0.52**	0.29	0.44**	-0.47**	0.08	0.84**	0.87**	-0.10	-0.43**	1.00
	P	0.63**	0.73**	-0.15	0.46**	0.29	0.41*	-0.40*	0.03	0.82**	0.81**	-0.10	-0.40*	1.00

Table 5: Genotypic and Phenotypic Correlation Co-Efficient among Thirteen Characters of Rice Genotypes under Stress Condition

		PH	FLL	FLB	FLA	FLAn	RL	RSR	T/P	PL	FG	SF	TW	YP
PH	G	1.00												
	P	1.00												
FLL	G	0.79**	1.00											
	P	0.72**	1.00											
FLB	G	-0.56**	-0.39*	1.00										
	P	-0.52**	-0.34*	1.00										
FLA	G	-0.04	0.29	0.77**	1.00									
	P	-0.03	0.35*	0.76**	1.00									
FLAn	G	-0.47**	-0.47**	0.16	-0.16	1.00								
	P	-0.41*	-0.44**	0.14	-0.16	1.00								
Rl	G	0.89**	0.92**	-0.41*	0.20	-0.67**	1.00							
	P	0.88**	0.84**	-0.39*	0.18	-0.63**	1.00							
RSR	G	0.36*	0.72**	-0.07	0.42*	-0.74**	0.74**	1.00						
	P	0.31	0.62**	-0.07	0.35*	-0.68**	0.72**	1.00						
T/P	G	0.42**	0.66**	-0.31	0.13	-0.85**	0.73**	0.89**	1.00					
	P	0.33	0.54**	-0.23	0.14	-0.64**	0.59**	0.72**	1.00					
PL	G	0.20	0.36*	0.13	0.36*	0.04	0.33	0.35*	0.15	1.00				
	P	0.18	0.29	0.11	0.30	0.05	0.29	0.28	0.08	1.00				
FG	G	0.56**	0.53**	-0.20	0.15	-0.42*	0.56**	0.32	0.20	0.59**	1.00			
	P	0.54**	0.49**	-0.19	0.15	-0.40*	0.54**	0.31	0.18	0.57**	1.00			
SF	G	0.40*	0.66**	-0.25	0.21	-0.78**	0.61**	0.66**	0.73**	-0.21	0.30	1.00		
	P	0.39*	0.62**	-0.24	0.20	-0.74**	0.60**	0.63**	0.64**	-0.19	0.30	1.00		
TW	G	-0.28	0.11	0.24	0.34*	-0.65**	0.13	0.67**	0.67**	-0.23	-0.17	0.68**	1.00	
	P	-0.25	0.10	0.21	0.29	-0.59**	0.12	0.60**	0.52**	-0.22	-0.17	0.65**	1.00	
YP	G	0.46**	0.72**	-0.11	0.38*	-0.68**	0.67**	0.69**	0.65**	0.59**	0.82**	0.62**	0.29	1.00
	P	0.44**	0.64**	-0.10	0.3*	-0.61**	0.65**	0.65**	0.52**	0.52**	0.79**	0.59**	0.29	1.00

PH: Plant Height (cm); **FLL:** Flag Leaf Length (cm); **FLB:** Flag Leaf Breadth (cm); **FLAn:** Flag Leaf Angle (^{0}); **RL:** Root Length (cm); **RSR:** Root to Shoot Ratio; **T/P:** Number of Tillers/Plant; **PL:** Panicle Length (cm); **FG:** Filled

Grains/Panicle; **YP:** Yield/Plant (g); **SF:** Spikelet Fertility % ; **TW:** Test Weight; **NS:** Non Stress; **S:** Stress.

Table 6: Direct (Diagonal Values) & Indirect Effects of 13 Different Characters on Grain Yield at Genotypic Level under Both Hydrological Regimes

		PH	FLL	FLB	FLA	FLAn	RL	RSR	T/P	PL	FG	SF	TW
PH	**NS**	**-9.29**	0.36	0.74	0.66	-0.20	5.26	3.20	0.08	-0.25	0.15	0.03	-0.07
	S	**23.60**	50.17	-51.42	3.74	-1.00	-33.44	5.40	1.41	-0.22	0.95	1.09	0.19
FLL	**NS**	-8.16	**0.41**	0.50	1.00	-0.17	5.61	1.82	0.04	-0.36	0.18	0.01	-0.05
	S	18.64	**63.52**	-36.12	-25.00	-1.08	-34.59	10.96	2.19	-0.40	0.89	1.79	-0.08
FLB	**NS**	3.49	-0.10	**-1.96**	1.04	0.80	0.03	-3.25	-0.18	0.03	-0.09	0.02	0.02
	S	-13.11	-24.78	**92.59**	-67.08	0.36	15.38	-1.13	-1.04	-0.14	-0.33	-0.68	-0.16
FLA	**NS**	-3.66	0.25	-1.22	**1.67**	0.50	4.66	-1.34	-0.12	-0.26	0.06	0.01	-0.03
	S	-1.01	18.22	71.27	**-87.14**	-0.37	-7.62	6.40	0.44	-0.40	0.26	0.57	-0.23
FLAn	**NS**	1.55	-0.06	-1.28	0.68	**1.22**	-1.15	-0.42	-0.12	-0.20	0.04	0.07	-0.04
	S	-10.28	-29.87	14.51	14.11	**2.30**	24.98	-11.19	-2.80	-0.05	-0.70	-2.11	0.44
Rl	**NS**	-7.14	0.34	-0.01	1.14	-0.21	**6.85**	-0.34	-0.03	-0.19	0.07	-0.02	-0.02
	S	21.02	58.52	-37.92	-17.68	-1.53	**-37.55**	11.23	2.42	-0.36	0.94	1.66	-0.08
RSR	**NS**	5.47	-0.14	-1.17	0.41	0.09	0.43	**-5.43**	-0.15	0.15	-0.14	-0.06	0.08
	S	8.40	45.87	-6.91	-36.78	-1.69	-27.80	**15.17**	2.94	-0.39	0.54	1.79	-0.45
T/P	**NS**	3.43	-0.08	-1.66	0.94	0.73	1.06	-3.99	**-0.21**	0.01	-0.10	-0.11	0.05
	S	10.04	42.06	-28.96	-11.51	-1.94	-27.51	13.48	**3.31**	-0.17	0.34	1.97	-0.46
PL	**NS**	-4.28	0.27	0.12	0.80	0.44	2.38	1.49	0.01	**-0.55**	0.17	0.03	-0.04
	S	4.73	22.55	11.77	-31.65	0.10	-12.23	5.34	0.50	**-1.11**	1.00	-0.56	0.16
FG	**NS**	-5.90	0.31	0.76	0.42	0.20	1.89	3.29	0.09	-0.40	**0.24**	0.03	-0.07
	S	13.24	33.39	-18.15	-13.31	-0.96	-20.88	4.86	0.66	-0.66	**1.69**	0.82	0.11
SF	**NS**	1.45	-0.01	0.17	-0.10	-0.40	0.51	-1.52	-0.11	0.07	-0.04	**-0.20**	0.09
	S	9.46	42.08	-23.21	-18.34	-1.79	-23.01	10.04	2.41	0.23	0.51	**2.71**	-0.46
TW	**NS**	4.91	-0.17	-0.23	-0.35	-0.37	-0.93	-3.26	-0.08	0.18	-0.12	-0.14	**0.13**
	S	-6.65	7.04	22.17	-29.55	-1.50	-4.68	10.09	2.23	0.26	-0.28	1.85	**-0.68**

PH: Plant Height (cm); **FLL:** Flag Leaf Length (cm); **FLB:** Flag Leaf Breadth (cm); **FLAn:** Flag Leaf Angle (^{0}); **RL:** Root Length (cm); **RSR:** Root to Shoot Ratio; **T/P:** Number of Tillers/Plant; **PL:** Panicle Length (cm); **FG:** Filled Grains/Panicle; **YP:** Yield/Plant (g); **SF:** Spikelet Fertility %; **TW:** Test Weight; **NS:** Non Stress; **S:** Stress

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